SOIL CHARACTERISTICS FOR THE GOWTH OF TANDUI (Mangifera rufocustata Kostrem.) IN THE SOUTH KALIMANTAN, INDONESIA

by Kehutanan turnitin

SOIL CHARACTERISTICS FOR THE GOWTH OF TANDUI (*Mangifera rufocustata* Kostrem.) IN THE SOUTH KALIMANTAN, INDONESIA

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ABSTRACT

Forest exploitation may cause decreasing soil fertility, which in turn causes the threat for Tandui (Mangifera rufocustata Kostrem.) population, a forestry plant used as a diabetes medicine. Observation on soil physical and chemical characteristics was conducted on site of the District of Hulu Sungai Selatan, Indonesia in where Tandui can still be found growing well. Results of study showed that soils for Tandui growth generally had a texture from sandy clay loam to clay, with bulk density ranging from 0.97 to 1.42 g cm^{-3}. Soils for Tandui growth also have a pH in the range of 4.48−7.31, where a relatively high pH is associated with high exchangeable Ca contents. Analysis of soil fertility status showed that the soil had low to moderate levels of soil fertility. This study demonstrated that although Tandui may grow well on soils with low soil fertility status, nutrient management practices are required to improve the growth of this plant.

Keywords: soil chemical characteristics, soil fertility, organic C, soil physical characteristics

INTRODUCTION

Kalimantan Island is a phytogeographic area of Malesia and has tropical rain forests that are rich in biodiversity and ecosystem (Koh et al., 2013; Mackinnon et al., 2000). The rate of forest conversion in Indonesia is very high, about at 2.0–2.8 million hectares year^{-1} (Daryono, 2009; Indonesia Forest Watch, 2014). The causes of deforestation in Indonesia are the development of the timber industry, plantations, sedentary agriculture, shifting cultivation, road construction and infrastructure, mining and irregular logging. Increasing population of people living around the forest may also become a threat to forest sustainability. Kusmana and Susanti (2015) stated that human activities disrupt the succession process, deliver pressures and disturbances in the systems. Deforestation also decreases the hydrological functions, increasing the rate of extinction and global warming (Indonesia Forest Watch, 2014).

Natural forest with various tree species produces different quality of leaf litter. Natural regenerating forest stands produce nutrient cycles and better soil quality, forest ecosystems and climate factors that determinants of stand regeneration. Land conversion results the loss of natural vegetation, decrease the soil quality which is indicated by decreasing soil organic carbon content (Baldassini and Paruelo, 2020), which in turn led to decreasing soil fertility. Soil fertility indicators may be measured by determining the physical and chemical properties of the soils. Measurement of soil chemical properties included soil pH, organic C content, total N, available P, total K, exchangeable cations (K, Na, Ca, and Mg), and cation exchangeable capacity (CEC) (Massenssini et al., 2015). Suin (2012) limited the measurement of soil physical factors to soil texture, bulk density, porosity and permeability. Soil fertility may also be characterized using bioindicators of ecosystems or habitats (Kripa et al., 2013; Pratiwi, 2010; Zulkifli and Setiawan, 2011) and sensitive groups of organisms in response to the environmental pressure.

Tandui (*Mangifera rufocustata* Kostrem.) is medicinal plants, which is contributed to non-timber forest products (NTFP). Local people believed that Tandui peel was used as a diabetes medicine (Andri and Rafieq, 2015; Nurmalinda et al., 2015). Another study has shown that Tandui that belonging to the *Mangifera* family have value as medicinal plants (Ribeiro et al., 2007). Tandui's wooden logs also have a high selling value, so most of the Tandui plants are cut down. Continuous removal of the bark of the Tandui for medicinal use also results in the death of Tandui. International Union for Conservation of Nature (IUCN) categorizes the Tandui in the red list (vulnerable), which indicates that Tandui is leading to critical and extinction (Red, 2010). Altough Tandui may still be found in the forest, the number of this plant has decreased significantly (Rafieq and Fakhrina, 2015). Decreasing the population of Tandui may also be related to the decreasing level of soil fertility that has changed due to forest exploitation. Although there have been many previous studies on soil characterization of forest soils, so far there has been no research that has carried out to characterize soils in where Tandui growth. This study aimed to characterize the physico-chemical properties of the soils under Tandui growth.

MATERIALS AND METHODS

Sampling Site

This research was conducted in a forested area in the Hulu Sungai Selatan Regency, South Kalimantan, Indonesia (2°29′ 59″−2°56'10″ S and 114°51′19″−115°36'19″ E). Lands in Hulu Sungai Selatan Regency consists of secondary forest, bush forest, swampy forest, and industrial plantation forest. The annual rainfall in this area was in the range of 2253−2926 mm, with the driest month in August with average of 91.49 mm and the wettest month was observed in November with 390.38 mm of rainfall. The average temperature of this area was 27.20−27.73 °C, with the minimum temperature was 21.25−22.25 °C and the maximum temperature was 33.15−33.90 °C.

The observation of the soil where Tandui grows were carried out on 6 observation points. The location of Tandui tamarind grows was obtained from the Banjarbaru Environmental and Forestry Research and Development Center (BP2LHK), the Forest Stakeholder Unit (KHP) of South Kalimantan Province, and the information of local people. The location of the observations on these soil characteristics is presented in Figure 1.

Sampling and Characterization of Soils

Soil samples were cored from 6 different locations, in which 4 soil samples were collected 10 meters from the north, south, west and east of the Tandui, respectively for each location. Soil samples were taken at a depth of 0–30 cm at each sampling point using a soil auger, then the collected soil samples were cleaned for litter and plant roots, then soil cores from the same location were mixed and homogenized to produce one composite sample. Soil samples then were put into plastic bags and transported to the laboratory.

Determination of soil physical properties in the laboratory included soil texture (Gee and Bander, 1986), density and permeability of soil (Blake and Hartge, 1986). Soil chemical characterization were soil organic C-content (Nelson and Sommers, 1996), N-total content (Bremer and Mulvaney, 1982), P-total and K-total extracted with 25% HCl (Sudjadi et al., 1971), exchangeable bases (Na, K, Ca and Mg) (CEC) (Lanyon and Heald, 1982), and cation exchangeable capacity (Rhoades, 1982).

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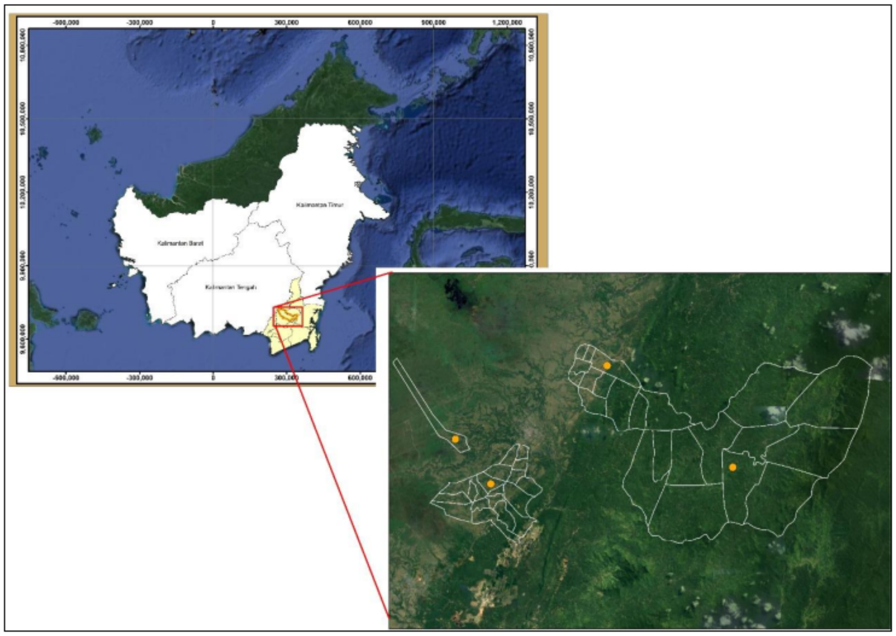

Figure 1. Sampling site for the characterization of soils grown with Tandui (*Mangifera rufocustata* Kostrem.) in the Regency of Hulu Sungai Selatan, South Kalimantan, Indonesia

Data Analysis

The results of soil physical and chemical characterization were used to determine the level of soil fertility at each location of Tandui. The determination of soil fertility level at each location of Tandui was carried out based on the criteria of the valuation of soil chemical properties developed by the Bogor Soil Research Institute (1983). Soil characteristics and fertility levels at each location were then analyzed using descriptive statistical analysis.

RESULTS AND DISCUSSION

Soil Physical Characteristics

The physical properties of the soils showed that the soils had a relatively high clay content, varying from the lowest 24.54% (Amparaya 1) to the highest 62.36% (Telaga Langsat 1). The high clay content produced soil texture that varies from sandy clay loam to clay (Table 1). The high clay content also affected the high bulk density, which in turn affected the porosity of the soils. The soil bulk density of Tandui growth was in the range of 0.97−1.42 g cm^{-3} (Table 1). This result is in line with research conducted by Ding et al. (2016) who reported a closely-positive correlation between pore size distribution and soil texture that is observed in 78 soil samples with a wide range of soil texture.

Table 1. Soil physical characteristics

Location	Soil Fraction (%)			USDA Soil Texture	Bulk Density (g cm^{-3})	Permeability (cm hour^{-1})
	Sand	Silt	Clay			
Telaga Langsat 1	7.69	29.96	62.36	Clay	1.34	2.34
Telaga Langsat 2	19.96	20.39	59.65	Clay	1.41	3.45
Amparaya 1	59.53	15.93	24.54	Sandy clay loam	0.97	6.32
Amparaya 2	43.57	24.86	31.58	Clay loam	1.12	2.54
Sungai Raya	5.32	40.16	53.52	Silty clay	1.42	3.87
Tumingkih	15.51	33.22	51.27	Clay	1.34	4.32

The results of this study are in agreement with previous studies which also reported high clay content in several locations of land reclaimed from coal mining activities. Sukarman and Gani (2020) reported high clay content and varying soil texture from clay loam to clay in reclaimed-mining soils at several locations in South Kalimantan. Clay content ranging from 40-70% and high bulk density were also observed in reclaimed-mining soils with different reclamation ages (Saidy, 2015). The results indicate the need of soil management at the location of Tandui to ensure that the growth and production of the Tandui is not limited by soil physical properties.

Soil Chemical Characteristics

The results of the observations on organic C, total N, P_2O_5, and K_2O content of soils at several observation locations are described in Figure 2. Contents of organic C of these soils varied from 14.2 g kg^{-1} (Amparaya 1) to 21.1 g kg^{-1} (Telaga Langsat 1), and these ranges are classified as low−moderate levels of organic C in soils based on the soil criteria issued by the Bogor Soil Research Institute (1983). The results of this study are in accordance with previous research conducted by Kumar et al. (2012) who reported low organic C content in 50 soil samples with plants belonging to the *Mangifera,* family belonging to Tandui, in India. Organic C in soils plays an important role in controlling soil fertility (Bonanomi et al., 2020; Sharma et al., 2020), due to the application of organic C to soils improving soil physical, chemical, and biological properties (Marín-Martínez et al., 2021; Wu et al., 2020). The low organic C content in this study indicates the need for soil management to increase soil organic C content to support the growth and productivity of Tandui. The N content in this soil also varies from 1.7 g kg^{-1} (Amparaya 1) to 3.8 g kg^{-1} (Telaga Langsat 10), and is within the criteria for low-moderate levels (Figure 2). The P_2O_5 content in the soil varies very significantly, being in the range of 0.11−0.95 g kg−1 which is classed at the level of very low to very high.

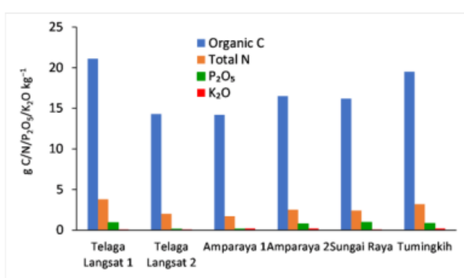

Figure 2. Contents of organic C, total N, P_2O_5, and K_2O of soils for Tandui growth observed at several locations

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The high soil pH in the soils of the forest of Kalimantan that was observed is different with the previous observations. Research conducted by Ifansyah (2014) showed that Ultisols soil which is the dominant soil type in forests in South Kalimantan has a pH of 4.0 (very acidic). Soil in forests in Kalimantan used for coal mining has a pH in the range of 4.57−4.62 (Paranoan, 2019). The neutral and near-neutral soil reaction on the soil with Tandui is related to the soil management that was carried out by the application of lime. This assumption is supported by the fact that at the point of observation with a pH >5.0, high content of exchangeable Ca was observed, ranging from 6.55 cmol kg^{-1} to 22.60 cmol kg^{-1} (Table 2). Several previous studies have shown that an increase in the exchangeable Ca content will be followed by an increase in soil pH (Cremer and Prietzel, 2017; Wang et al., 2018).

Table 2. Soil pH, exchangeable cations and aluminium, and cation exchangeable capacity (CEC) of soils for Tandui growth observed at several locations

Location	pH H_2O	Ca	Mg	Na	K	Al	CEC
		------- cmol kg^{-1} -------					
Telaga Langsat 1	5.64	16.60	0.21	0.28	0.47	0.58	28.11
Telaga Langsat 2	4.48	3.74	0.10	0.05	0.03	2.24	30.37
Amparaya 1	5.80	6.55	0.10	0.05	0.07	0.55	22.58
Amparaya 2	7.31	20.43	0.10	0.11	0.15	0.00	27.24
Sungai Raya	6.41	14.56	0.10	0.11	0.30	0.00	31.11
Tumingkih	6.37	22.60	0.10	0.11	0.07	0.00	33.74

The high soil pH and exchangeable Ca content in the soil of Tandui made the exchangeable Al content become very low, it was not detected by the method used in this study at several locations. Al-exchange content in this study ranged from undetectable to 2.24 cmol kg^{-1} (Table 2). Cation exchangeable capacity (CEC) is the ability of the soil to exchange the exchangeable cations in the soil exchange complex (Khaledian et al., 2017). Thus, CEC is an important parameter in indicating the level of soil fertility. The results of this study showed that the soil CECs in the study were in the range of 22.58−33.74 cmol kg^{-1}, and these CECs were classified as moderate-high levels based on soil criteria of the Bogor Soil Research Institute (1983).

Soil Fertility Status

Soil fertility is defined as the ability of the soil to provide nutrients in available forms, in sufficient and balanced quantities to support maximum plant growth and production (Nair, 2019).

Table 3. Level fertility of soils for Tandui growth observed at several locations based on the contents organic C, P_2O_5, K_2O, cation exchangeable capacity (CEC), and base saturation

Sampling Location	CEC	Base Saturation	P_2O_5	K_2O	Organic C	Level of Soil Fertility
Telaga Langsat 1	High	High	High	Low	Moderate	Moderate
Telaga Langsat 2	High	Low	Low	Low	Low	Low
Amparaya 1	Moderate	Low	Low	Moderate	Low	Low
Amparaya 2	High	High	High	Moderate	Low	Moderate
Sungai Raya	High	Moderate	High	Low	Low	Low
Tumingkih	High	High	High	Moderate	Low	Moderate

Thus, soil fertility status refers to soil status in providing nutrients for plant growth and production. The Bogor Soil Research Institute (1983) suggests a combination of 5 soil chemical characteristics, which are: CEC, base saturation, contents of P_2O_5, K_2O and organic C in soils for determining soil fertility status. The status of soil fertility for each location based on the criteria of the Bogor Soil Research Institute (1983) are presented in Table 3.

The results of the determination of fertility status showed that soil for Tandui growth had fertility status in the low to moderate class (Table 3). The results of this study indicate that Tandui may develop well on soils with varying levels of soil fertility from low to moderate. However, on soils with low soil fertility status, soil management needs to be carried out to ensure the continuity of growth and production of this plant. This is in line with several other studies showing the need for soil management in *Mangifera indica* L., a plant belonging to the same family with *Mangifera rufocustata* Kostre*m*. Kumari et al. (2020) reported the need for integrated nutrient management practices to increase soil fertility to increase mango production. Liming needs to be done to solve the acidity problem in mango cultivation, which in turn increase the base saturation for increasing mango production (Correia et al., 2018). The research results demonstrate that although *Mangifera rufocustata* Kostrem can grow and develop on soils with low soil fertility status, nutrient management practices are required to improve soil fertility and thereby increasing the growth and productivity of plant.

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